TITLE OF THE INVENTION

NON-CONTACTING CONVEYANCE EQUIPMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention holds a subject by non-contacting, and relates to the non-contacting conveyance equipment used for rotation etc.

2. Description of the Related Art

[0002] In recent years, integrated circuit cards, smart cards, etc., have spread, and such products have diversified. The wafers used in connection have become thin, and the diameter of wafers has increased. Wafers 0.5mm thick and 10 inches in diameter have been developed. Such thin and large wafers curve and crack easily.

[0003] Thus it is difficult to avoid cracking a wafer when conveying it to be processed or moving it within a processing stage for manufacturing integrated circuits. That is, the mechanical integrity of a wafer decreases as the diameter of the wafer increases, or as the thickness of the wafer decreases. For this reason, non-contacting conveyance equipment is proposed. Non-contacting conveyance equipment holds and conveys a wafer by non-contacting using air, nitrogen gas, and various similar things are already being put in practical use.

[0004] For example, in JP 11-254369, air is introduced through an air inlet into a chamber. Within the chamber, the air flows about a rotational flow generating plate and is then sent to the inside of a bell mouth. The air enters the bell mouth while turning, and is directed out of the bell mouth over a flat surface at the parameter of the bell mouth. An article to be carried rests within the bell mouth.

[0005] One problem associated with the device disclosed in JP11-254369 is that, because air is introduced from an inlet above the bell mouth, a large amount of air is necessary. In addition to consuming excess energy, increased air flow can be detrimental in a semiconductor clean room. That is, currents of air within the clean room can stir up dust and other debris. Dust and debris can cause defects in the circuits printed on the semiconductor wafers.

[0006] Moreover, with the non-contacting conveyance equipment which above-mentioned JP11-254369 proposes, the power of attracting and holding a conveyed thing by making swirling fluid

can be improved because the feeding mouth, revolution room, and bell mouth of air are open for free passage in order, are complicated in structure and the equipment is costly to manufacture.

[0007] Moreover, since the equipment of JP11-254369 is structurally complicated, miniaturization is difficult, the action range of the equipment is limited, and it is problematically inflexible.

[0008] Furthermore, the passage resistance that an air style receives, owing to complicated structure, becomes large. Therefore, in order to secure sufficient attraction maintenance power, a lots of air needs to be sent in, thereby decreasing energy efficiency, and making it difficult to save energy. Moreover, when a lot of air is dealt with in a clean room, dust soaring from floors etc. becomes a problem.

SUMMARY OF THE INVENTION

[0009] The present invention is proposed in view of the above. The equipment of the present invention can be manufactured with less cost, can be easily miniaturized, and has an extended range of action. Furthermore, the non-contacting conveyance equipment of the present invention can also realize energy curtailment.

[0010] The above-mentioned purposes can be attained by non-contacting conveyance equipment having a concave opening, and end piece and a fluid passageway. The concave opening has a continuous walled inner peripheral surface. The end face opposes the object to be conveyed and is formed in the concave opening. The fluid passageway has a spout facing the inside of the concave opening, to supply fluid to the inner peripheral surface of the concave opening so as to cause a swirl of fluid within the concave opening. A plurality of spouts face may be provided to face the inside of the concave opening such that the plurality of spouts together cause the swirl of fluid within the concave opening.

[0011] A plurality of concave openings may be provided on a base, each concave opening having an end face formed therein and a fluid passageway comprising a spout facing the inside thereof. In this case, the spouts of the concave openings may face different directions such that fluid swirls in a clockwise direction in a first portion of the concave openings and fluid flows in a counter clockwise direction in a second portion of the concave openings. The base may be surrounded with a peripheral edge to block a flow of fluid off the base.

[0012] The base may have a center with a center swirl formation object formed substantially

at the center of a base and a plurality of fluid swirl formation objects arranged around the center swirl formation object. The center swirl formation object is similar to the fluid swirl formation objects except that an inner wall may be formed within the concave opening of the center swirl formation object so as to form a channel between an outer surface of the inner wall and the inner peripheral surface of the concave opening.

[0013] The fluid supplied through the spout may be ionized. In addition, or in the alternative to, ionization, the fluid may be air, which is vibrated with an ultrasonic frequency.

[0014] Centering protrusions may be radially displaced from a center of the non-contacting conveyance equipment. A centering mechanism may vary the radial distance of the centering protrusions from the center of the non-contacting conveyance equipment.

[0015] With the invention, a spout faces the inside of a concave opening to supply fluid to an inner peripheral surface. According to one aspect of the invention, this configuration allows for objects to be conveyed using the less air than was previously possible. Accordingly, energy consumption is reduced. Perhaps more importantly, this aspect of the invention minimizes the air currents generated while conveying objects. If used in a semiconductor clean room, less dust and debris may be stirred up by the non-contacting conveyance equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention will be readily understood by reference to the following description of embodiments described by way of example only, with reference to the accompanying drawings in which like reference characters represent like elements, wherein:

[0017] Figs. 1A and 1B are perspective views of the first embodiment of non-contacting conveyance equipment, where Fig. 1A is a view from a slanting lower point, and Fig. 1B is a view from a slanting upper point.

[0018] Figs. 2A and 2B are cross sectional views of the non-contacting conveyance equipment shown in Fig. 1A, where Fig. 2A is a view taken through the I-I line of Fig. 1A, and Fig. 1B is a view taken through the II-II line of Fig. 1A.

[0019] Figs. 3A and 3B are perspective views of the second embodiment of non-contacting conveyance equipment, where Fig. 2A is a view from a slanting lower point, and Fig. 2B is a view from a slanting upper point.

[0020] Figs. 4A and 4B are views of the non-contacting conveyance equipment shown in Figs. 3A and 3B, where Fig. 4A is a bottom view of Fig. 3A, and Fig. 4B is a view taken through the III-III line of Fig. 3B.

[0021] Fig. 5 is a cross sectional side view of the third embodiment of non-contacting conveyance equipment.

[0022] Fig. 6 is a top view of the third embodiment of non-contacting conveyance equipment.

[0023] Fig. 7 is an action diagram of the centering mechanism, viewed through the IV-IV line of Fig. 5.

[0024] Fig. 8 is a perspective view, from a slanting upper point, of the fourth embodiment of non-contacting conveyance equipment.

[0025] Figs. 9A and 9B are views of the non-contacting conveyance equipment shown in Fig. 8, where Fig. 9A is a top view, and Fig. 9B is a view taken through the V-V line of a Fig. 9A.

[0026] Fig. 10 is a perspective view of the fifth embodiment of non-contacting conveyance equipment, shown individually with solid lines, and shown with dotted lines as inserted into a wafer cassette.

[0027] Fig. 11 is a top view of the non-contacting conveyance equipment, shown in Fig. 10, inserted in the wafer cassette.

[0028] Fig. 12 is a horizontal sectional view of the non-contacting conveyance equipment shown in Figs. 10 and 11.

[0029] Fig. 13 is a perspective view of the sixth embodiment of non-contacting conveyance equipment.

[0030] Fig. 14 is a partial front sectional view of the seventh embodiment of non-contacting conveyance equipment.

[0031] Fig. 15 is a partial front sectional view of the eighth embodiment of the non-contacting conveyance equipment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] The present invention will now be described with reference to embodiments and examples which are given by way of example only, not limitation.

[0033] Figs. 1A and 1B are perspective views of the first embodiment of non-contacting conveyance equipment, where Fig. 1A is a view from a slanting lower point, and Fig. 1B is a view from a slanting upper point. Figs. 2A and 2B are cross sectional views of the non-contacting conveyance equipment shown in Fig. 1A, where Fig. 2A is a view taken through the I-I line of Fig. 1A, and Fig. 1B is a view taken through the II-II line of Fig. 1A. In these views, the non-contacting conveyance equipment 1 of the present invention is equipment which holds and (chinning-exercises floatage) conveys a subject (here wafer 9) by non-contacting. Moreover, this equipment is constructed using a pillar-shaped fluid swirl formation object 2. The non-contacting conveyance equipment 1 of the present invention is equipped inside with the circumference-like concave part 3. The equipment 1 has the subject and flat-end-face 2b which counters formed in the opening side of the concave part 3. A fluid passage 5 supplies fluid to a spout 4, which faces the inside of the concave part 3 and breathes the fluid out along a direction tangential to an inner circumference of the concave part 3 and into the concave part 3.

[0034] A fluid introduction mouth 6 is prepared in a closed-face 2a of the fluid swirl formation object 2 by drilling perpendicular to the closed-face 2a until reaching the fluid passage 5, which is drilled horizontally to reach the spout 4, which faces the inside of the concave part 3. That is, the fluid passage 5 provides free passage from the fluid introduction mouth 6 to the spout 4, and makes supply fluid breathe out along the direction tangential to the inner circumference of the concave part 3 and into the concave part 3 from the spout 4. By this arrangement, fluid is supplied such that a fluid swirl occurs inside the concave part 3.

[0035] The fluid introduction mouth 6, the fluid passage 5, and a set of the two spouts 4 are formed, and the fluid (here air) which blows off from the set of two spouts 4 is breathed out in the same direction along the direction of a circumference, and thereby the spouts mutually create a fluid swirl of slight strength.

[0036] Moreover, slope 3a is formed of camfering and the diameter of the opening edge of the concave part 3 is expanded in the shape of a trumpet. Therefore, the fluid swirl generated in the concave part 3 can flow now out of the concave part 3 promptly by this slope 3a.

[0037] In the non-contacting conveyance equipment 1 of the above-mentioned construction, if air is supplied to the fluid introduction mouth 6 from air supply equipment (not shown), the air will be blown into the concave part 3 from the spout 4 through the fluid passage 5. The air becomes a fluid swirl, and is resupplied in the internal space of the concave part 3. The resupplied swirling air then flows out of the concave part 3. If the wafer 9 is arranged in a position counter to the flat-end-face 2b of the fluid swirl formation object 2, then at the time of the outflow, since air will serve as a high-speed style and will flow out along with flat-end-face 2b, negative pressure occurs between flat-end-face 2b and the wafer 9. Therefore, the wafer 9 is pushed by surrounding atmospheric pressure, and is attracted to the flat-end-face 2b side. The air that is between the flat-end-face 2b and the wafer 9 receives restitution, and the wafer 9 comes to be held in balance counter to flat-end face 2b and by non-contacting.

[0038] Thus, in the first embodiment of the present invention, the wafer 9 is held with fluid swirl formation object 2, simply formed with the concave part 3, the flat-face 2b, and the fluid passage 5. The equipment can be easily constructed, and the cost of manufacturing the equipment can be greatly reduced.

[0039] Moreover, since the equipment can be easily constructed, it can also be easily miniaturized. When miniaturized, the equipment can be inserted in previously unconventional spaces, its range of action may be extended, and its conveyance movement in a narrow domain within the same process and processing equipment can be performed more freely.

[0040] Moreover, since the fluid is resupplied in accordance with an inside that allows the fluid to be blown into the concave part 3, a fluid swirl is created; the fluid swirls smoothly, and with reduced passage resistance. Therefore, energy efficiency is raised and energy use is curtailed.

[0041] Furthermore, the equipment blows fluid off along the direction of a circumference inside the concave part 3. Since this generates a fluid swirl, the power of the attractive power of the negative pressure between flat-face 2b and the wafer 9 is markedly improved as compared with the conventional thing, and becomes powerful.

[0042] In addition, although the above embodiment describes two sets of devices (a fluid introduction mouth 6, a fluid passage 5, and a spout 4), one such set is sufficient, and three or more sets may also be used.

[0043] Moreover, although the fluid introduction mouth 6 is provided for each set of devices,

one fluid introduction mouth 6 may feed plural elements. That is, one fluid introduction mouth may branch off to supply plural fluid passages 5 and plural spouts 4.

[0044] Furthermore, although the fluid passage 5 was formed in the combination of a vertical course and a horizontal course, it is not limited to such a course. It is only necessary to form the fluid passage 5 so that air may be spouted along the direction of a circumference of the concave part 3 from the fluid introduction mouth 6.

[0045] Next, a second embodiment of the non-contacting conveyance equipment of the present invention is explained, with reference to Figs. 3 and 4. Some of the equipment of the first embodiment, described above, is used in this second embodiment, the same reference numeral is given to the same equipment, and a duplicate explanation is omitted.

[0046] Figs. 3A and 3B are perspective views of the second embodiment of non-contacting conveyance equipment, where Fig. 2A is a view from a slanting lower point, and Fig. 2B is a view from a slanting upper point. Figs. 4A and 4B are views of the non-contacting conveyance equipment shown in Figs. 3A and 3B, where Fig. 4A is a bottom view of Fig. 3A, and Fig. 4B is a view taken through the III-III line of Fig. 3B.

[0047] Two or more fluid swirl formation objects 2, as explained in the first embodiment, are used in the non-contacting conveyance equipment 11 of the second embodiment. The non-contacting conveyance equipment 11 is equipped with a support object 12 comprised of a peripheral surface 14 installed in a base 13 and at the perimeter of the base 13. Four fluid swirl formation objects 2 are attached in the base 13 of the support object 12.

[0048] Each of the four fluid swirl formation objects 2 is attached in the inside (base field) of the base 13 by their closed-face sides 2a. Moreover, they are supported so that their flat-end-faces 2b mutually form a same side. The height of the peripheral surface 14 is adjusted so that its end face 140 also forms the side mutually formed by the flat-end-faces 2b. Furthermore, the chamber fin 141 is formed in the shape of two steps in a part of the inner periphery of end face 140 of the peripheral surface 14.

[0049] Corresponding to each of the fluid swirl formation objects 2, a fluid supply mouth 15 is formed in the external surface 130 of the base 13. The base passageway 131, to which each of the fluid supply mouths 15 and two fluid introduction mouths 6 of the corresponding fluid swirl formation object 2 is connected is branched and formed in the wall inside of the body part of the

base 13 from the fluid supply mouth 15 (Fig. 4 (b)).

[0050] A supply mouth 15 in the base 13 connects to the base passageway 131 that is formed in the wall of base 13, and branches out to connect to the fluid introduction mouths 6.

[0051] Five fluid outlets 16, other than the four above-mentioned fluid supply mouths 15, are formed in the external surface 130 of the base 13. The discharge passages 132, which lead to each of the fluid outlets 16, are installed through the wall inside of the body part of the base 13, and connect the fluid outlets 16 to the support object 12.

[0052] Furthermore, the attachment piece 171 is protruded on four places at predetermined intervals at the peripheral surface 14 of the support object 12. Nearly cylindrical lateral movement prevention guides 172 are installed in the attachment piece 171. The end sides of these lateral movement prevention guides 172 are projected to the plane mutually formed by the end face 140 of the peripheral surface 14, and each flat-end-face 2b.

[0053] In the non-contacting conveyance equipment 11 of the above-mentioned construction, if the air from air supply equipment (not shown) is sent to the fluid supply mouth 15, the air will be blown into the concave part 3 from the spout 4 through the base passageway 131, the fluid introduction mouth 6, and the fluid passage 5. The air becomes a fluid swirl, and is resupplied in the internal space of the concave part 3, and the air then flows out of the concave part 3. When the fluid swirls hold the wafer 9 by non-contacting, the rotational direction of the fluid swirls are beforehand mutually adjusted so that the wafer 9 does not rotate. For example, as shown in Fig. 4A, by arrangement of the spouts 4, the fluid swirls clockwise in two of the fluid swirl formation objects 2, and counterclockwise in the other two fluid swirl formation objects 2.

[0054] As in the case of the above-mentioned first embodiment, if the wafer 9 is arranged in a position counter to flat-faces 2b of the fluid swirl formation objects 2 at the time of the outflow of each fluid swirl, the wafer 9 will be held by non-contacting in response to the attractive power of the negative pressure created by the restitution of the air flow where flat-face 2b is countered. Movement of the wafer 9 is also guided and prevented by lateral movement prevention guides 172, which are particularly useful if the wafer 9 moves when the support object 12 is moved in the state of manufacturing. That is, non-contacting conveyance equipment 11 holds and conveys the wafer 9 by non-contacting.

[0055] Airflow passing though flat-end-face 2b from concave part 3b goes into the internal

space of the support object 12. It passes along the discharge passage 132 and the fluid outlet 16, after which it is compulsorily discharged with the exhaust (not shown).

[0056] Moreover, the flow that reaches the peripheral surface 14 is disturbed and resisted by the chamber fin 141 of the peripheral surface 14. For this reason, less air escapes over the end face 140 of the peripheral surface 14, decreasing outflow. Therefore, most air flow stays in the internal space and discharges by passing along the discharge passage 132 and out the fluid outlets 16.

[0057] Moreover, the lateral movement prevention guides 172 are formed outside of the peripheral surface 14. If the wafer 9 held by non-contacting tends to move or deviate horizontally, this movement is prevented, and the wafer 9 is stabilized during conveyance by the lateral movement prevention guides 172.

[0058] Fig. 3 shows the second embodiment of the present invention, which may be constructed using the easily constructed fluid swirl formation objects 2 of the first above-mentioned embodiment.

[0059] For this reason, the embodiment also may realize the benefits of minimization and energy savings. Moreover, since it is made to attract the wafer 9 by the fluid swirl formed in the concave part 3, the power of attraction can be made markedly powerful.

[0060] Moreover, since it may be made to generate the fluid swirls in four places, the wafer 9 may be attracted more powerfully over the whole of the wafer 9. Therefore, it becomes possible to correct curvature over the whole wafer 9, and the curvature reform power also becomes powerful. Consequently, when the wafer 9 is large, and even in the case where it moreover curved, the wafer can be certainly held by non-contacting, and where conveyance is also stabilized, it can carry the wafer 9 with greater certainty.

[0061] Moreover, each fluid swirl formation object 2 has a simple construction that blows air into the concave part 3 and forms a fluid swirl directly. For this reason, a stable fluid swirl with the non-contacting maintenance power is used. Four fluid swirl formation objects 2 become uniform with each other, and non-contacting maintenance of the wafer 9, which formerly tended to become a little unstable, can be performed with sufficient stable balance.

[0062] Furthermore, due to the maintenance power in which it does not contact is powerful, if the whole non-contacting conveyance equipment 11 reverses direction, a maintenance state is

maintainable as it is. Moreover, the wafer 9 can be reversed with the non-contacting conveyance equipment and can be conveyed to the following distance.

[0063] In addition, although the construction of this second embodiment establishes four fluid swirl formation objects 2, it is not so limited, and arbitrary numbers of fluid swirl formation objects 2 may be used.

[0064] Moreover, although the chamber fin 141 of the peripheral surface 14 was made into the shape of stairs, it is only necessary that the structure increase air resistance. Slot form, for example, also works to increase air resistance.

[0065] Furthermore, the fluid supply mouth, 15 and the fluid outlets 16 may be prepared in arbitrary numbers. However, at least three lateral movement prevention guides 172 need to be prepared.

[0066] Next, the third embodiment of the non-contacting conveyance equipment of the present invention is explained using Figs. 5, Fig.6, and Fig.7.

[0067] Fig. 5 is a cross sectional side view of the third embodiment of non-contacting conveyance equipment.

[0068] Fig. 6 is a top view of the third embodiment of non-contacting conveyance equipment.

[0069] Fig. 7 is an action diagram of the centering mechanism, viewed through the IV-IV line of Fig. 5.

[0070] The non-contacting conveyance equipment 21 of this third embodiment differs from the above-mentioned non-contacting conveyance equipment 11 of the second embodiment in that it is formed with a centering mechanism 200, for positioning a wafer 9, and for preventing lateral movement of the wafer 9 which is held by non-contacting.

[0071] The centering mechanism 200 is equipped with a rotary actuator 203 fixed on a base board 202 supported with a support 201 set up on an external surface 130 of the base 13. Moreover, the centering mechanism 200 is equipped with link arms 205, prepared toward the quarters of a perimeter edge of a flange 204, which is attached to a shaft (not shown) of the rotary actuator 203. Each of the link arms 205 has a crooked, long, and slender board material, one end of which is installed in the perimeter edge of the flange 204, and other end of which is

level. Moreover, a slot 206 for a guide is established in an attachment piece 209, which protrudes in a direction away from the external surface 130. A bolt is inserted in the slot 206, and the attachment piece 209 is established in the other end of the link arm 205. The centering guide (arm for centering) 207 can be screwed on and installed in the bolt, and the centering guide 207 can be slid along the slot 206 for a guide.

[0072] The centering mechanism 200 of the non-contacting conveyance equipment 21, constructed as above, operates as follows. First, air is sent into an air drive insertion mouth 208 of the rotary actuator 203, operating the rotary actuator 203. According to the operation, the flange 204 rotates through a predetermined angle, in the direction shown by the arrow 22 in Fig. 7(a) of the actuator 203, from the state of Fig. 7(a), to the state of Fig. 7(b); each link arm 205 moves according to the rotation. At this time, the centering guide 207, installed at the other one end of the link arm 205, is guided in the slot 206 as a guide of the attachment piece 209, and performs straight movement. The link arms 205 move only a predetermined distance in the direction of the center of the base 13, and then stop. The wafer 9, currently held by the non-contacting conveyance equipment 21, is regulated at the four quarters of the perimeter by lateral movement in a direction of the center of the centering guide 207. By such movement, the center of the wafer 9 comes to be positioned in alignment with the center of the internal space of the support object 12. On the other hand, regulation on the wafer 9 may be cancelled by rotating the flange 204 in an opposite direction to that shown by arrow 22. Thereby, the centering guide 207 moves in the direction that separates from the center of the base 13, and the wafer 9 held by non-contacting, is free to move laterally.

[0073] According to the operation of the rotary actuator 203, the centering guide 207 isolates or approaches only the same distance to the peripheral surface 14, respectively. And while holding the wafer 9 by non-contacting in the inner side, the wafer 9 is positioned with high precision. Therefore, when conveying the wafer 9 and arranging it in a predetermined position, it may be arranged with high precision. Therefore, the wafer 9 may be processed smoothly and accurately.

[0074] Next, the fourth embodiment of the non-contacting conveyance equipment of the present invention is explained with reference to Figs. 8 and 9.

[0075] Fig. 8 is a perspective view, from a slanting upper point, of the fourth embodiment of non-contacting conveyance equipment. Figs. 9A and 9B are views of the non-contacting

conveyance equipment shown in Fig. 8, where Fig. 9A is a top view, and Fig. 9B is a view taken through the V-V line of a Fig. 9A.

[0076] In the non-contacting conveyance equipment 31 of the fourth embodiment, a fluid swirl formation object 32 at the center of the equipment 31, and the fluid swirl formation objects 2 at the circumference of the equipment 31, are constructed differently. Two fluid swirl formation objects 2, arranged at the circumference of the equipment 31, have the same construction as used in the first, second, and third embodiments. However, the fluid swirl formation object 32 arranged at the center of the equipment 31 has the following construction.

[0077] Inside the concave part 33 of the fluid swirl object 32, a peripheral-wall 33a is prepared, forming a swirl passage 38, and a central hole 321. Moreover, a fluid introduction mouth 36 is formed so that the perimeter side of the fluid swirl formation object 32 may be faced. A fluid passage 35 is horizontally drilled in a thick part of the inside of the fluid swirl formation object 32, from the fluid introduction mouth 36, and reaching the spout 34 so that the fluid swirl passage 38 is attended. Air is breathed out, along the direction of a circumference of the fluid passage 38, into the fluid swirl passage 38 from the spout 34, and, swirling around at and in the fluid swirl passage 38, the air serves as a fluid swirl. The fluid introduction mouth 36, the fluid passage 35, and set of two spouts 34 are formed. The air which blows off from each of the spouts 34 is breathed out in the same direction along the direction of a circumference, and mutually form a fluid swirl mutually of slight strength.

[0078] Moreover, as shown in a Fig. 9 (b), the fluid supply mouths 15 prepared in the base 13 correspondingly join to the two fluid introduction mouths 36 of the fluid swirl formation object 32 located at the center. Moreover, one piece is prepared at a time in each of the fluid swirl formation objects 2 located towards the circumference of the case of the second embodiment.

[0079] Each of the fluid swirl formation objects 2 located towards the circumference is constructed so that their swirls rotate in mutually reverse directions.

[0080] In this fourth embodiment, the wafer 9 is held by non-contacting by the fluid swirl generated with the fluid swirl formation objects 2 and 32. So doing effects the same peculiar action demonstrated in the embodiments above.

[0081] That is, since the fluid swirl passage 38 was established in the center of the fluid swirl formation object 32, the air which flows in this fluid swirl passage 38 serves as a high-speed

fluid swirl. Therefore, the fluid swirls being more resupplied, the wafer 9, currently held by non-contacting, is rotated with strengthened torque and the wafer 9 rotates at high speed, to an extent not possible with a conventional non-contacting equipment. Equipment that carries out centrifugal separation and dries moisture adhered to the wafer 9 during a washing process, can be constructed using the fluid swirl formation object 32 to rotate the wafer 9 at high speed. Moreover, it can also serve as a washing machine that, by non-contacting, dries off and washes foreign substance adhering to the wafer 9, without cracking the wafer 9. Moreover, the rotation drive when detecting the orientation flat and V notch of the wafer, the rotation drive at the time of appearance inspection of the wafer, the rotation drive at the time of wafer etching, etc. can use it, being various.

[0082] The direction and intensity of the fluid swirl in the fluid swirl formation objects 2, for both are controlled by the amount of supply air. By such control, the high-speed rotation of the wafer 9 by the central fluid swirl formation object 32 is controllable at a proper rotation speed. Therefore, equipment 16 of the fourth embodiment can be appropriately used as a drier or as a washing machine.

[0083] Next, the fifth embodiment of the non-contacting conveyance equipment of the present invention is explained using Figs. 10, 11, and 12.

[0084] Fig. 10 is a perspective view of the fifth embodiment of non-contacting conveyance equipment, shown individually with solid lines, and shown with dotted lines as inserted into a wafer cassette. Fig. 11 is a top view of the non-contacting conveyance equipment, shown in Fig. 10, inserted in the wafer cassette. Fig. 12 is a horizontal sectional view of the non-contacting conveyance equipment shown in Figs. 10 and 11. Circumference-like concave parts 43 are inside the board-like base 42, which has a flat side 42b, in which the non-contacting conveyance equipment 41 counters the wafer 9 in these figures. Fluid passages 45 make air breathe out along the direction of an inner circumference of the concave parts 43, is formed into the concave parts 43, and consists of spouts 44 which face the insides of the concave parts 43.

[0085] The board-like base 42 consists of a base part 421 and two arm parts 422, which branch from the base part 421, forming two prongs of a fork. A grasping part 49, for enabling movement of the base 42, adheres to the end side of the base 421. The concave parts 43 are located in a line along each of the arm parts 422, three of the concave parts 43 to an arm part 422. Moreover, an E-like movement prevention guide 48 is formed in one of the concave parts

43 to an arm part 422.

[0086] As shown in Fig. 12, the fluid passages, installed in the two arm parts 422, pass to two fluid introduction mouths 46, which open to the side of the grasping part 49. The fluid passages 45 branch to the spouts 44 which attend the concave parts 43.

[0087] In the non-contacting conveyance equipment 41 of the above-mentioned construction, if the air from air supply equipment (not shown) is sent to the fluid introduction mouth 46, the air will be blown into each of the concave parts 43 from the spouts 44 through the fluid passages 45. The air becomes a fluid swirl, and is resupplied in the internal spaces of the concave parts 43, after which the air flows out of the concave parts 43. The direction of each of the fluid swirls, holding the wafer 9 by non-contacting, mutually may be adjusted beforehand so that the wafer 9 does not rotate. For example, as shown in Fig. 12, the three concave parts 43 of one arm part 422 are adjusted to swirl clockwise by changing the arrangement of the spouts 44, at three concave parts 43; the fluid swirls of the other arm part 422 are similarly arranged to swirl counterclockwise.

[0088] As is the case with each of the above-mentioned embodiments, when the wafer 9 is arranged in a position counter to the flat side 42b of the base 42, the outflow of each fluid swirl holds the wafer 9 in balance by the negative pressure created by the outflow of the fluid swirls, and by resupplying of the air flow by non-contacting, where flat side 42b is counter to the wafer. If the grasping part 49 is held in the state maintenance, and the board-like base 42 is moved, the wafer 9 will move with it, and the wafer 9 will be guided by the movement prevention guide 48. That is, the non-contacting conveyance equipment 41 holds and conveys the wafer 9 by non-contacting.

[0089] Since the base 42 of this non-contacting conveyance equipment 41 is thinly constructed in the shape of a board, as shown in Figs. 10 and 11, the board may be inserted into a narrow opening in a stack of wafers 9, which adjoin each other by the upper and lower sides, and which are held on shelves 81 of a wafer cassette 80.

[0090] Thus, in the fifth embodiment of the present invention, since it is made to attract the wafer 9 by the fluid swirls formed in each of the concave parts 43, as in the case of each above-mentioned embodiments, the power of attraction can be made powerful with a board-like base 42 holding the wafer fully secured. Therefore, non-contacting conveyance equipment 41 can be constructed in the shape of a board, capable of smoothly and freely accessing and attaining

wafers stacked in a wafer cassette 80, which is conventionally difficult to access. Moreover, in the case where the wafer cassette 80 is contained and loaded with the wafer, it can timely carry a wafer in to a desired position. That is, taking out from the wafer cassette 80 and carrying in to the wafer cassette 80 can be performed freely, thereby sharply increasing the working efficiency.

[0091] Furthermore, since the fluid swirls are formed at two or more places, and since the non-contacting maintenance power is powerful, even a wafer 9 that has curvature may be held by non-contacting maintenance in a state where its curvature is corrected. Moreover, even if the whole non-contacting conveyance equipment 41 is reversed, the maintenance state can be maintained, the wafer 9 is also reversed, and the wafer cassette 80 can also be loaded, reversed, and conveyed to a following distance.

[0092] In addition, although in the explanation above the board-like base 42 was constructed with two forks and so considered, and although the construction put three concave parts 43 in order at a time, these modes of construction are arbitrary and should given the construction suitable according to the use. For example, one arm instead of two forks may be considered, and an arm may be constructed with only one concave part 43. Moreover, the grasping part 49, although formed in this embodiment, is formed only if needed.

[0093] Next, the sixth embodiment of the non-contacting conveyance equipment of the present invention is explained using Fig. 13.

[0094] Fig. 13 is a perspective view of the sixth embodiment of non-contacting conveyance equipment. Non-contacting conveyance equipment 51 is equipped with fluid piping 58, which penetrates inside a fluid swirl formation object 52 to a circumference-like concave part 53, and also penetrates inside a long and slender pillar-shaped grasping part 57, and the fluid swirl formation object 52 is fixed to the end of the fluid piping 58 in Fig. 13.

[0095] The fluid introduction mouth 56 (which opens to the perimeter side of the concave part 53), the spout 54 (which is faced at the concave part 53), and the fluid introduction mouth 56 and spout 54 are prepared in the fluid passage 55 by the fluid swirl formation object 52. The fluid piping 58 is connected to the fluid introduction mouth 56, and air supplied from the fluid piping 58 is breathed out along the direction of a circumference through the fluid introduction mouth 56 and the fluid passage 55 in a concave 53 from a spout 54, and serves as a fluid swirl inside the concave part 53.

[0096] From a grasping part 57, two bent guide arms 591, 592 extend through the both sides of the concave part 53, and are bent perpendicularly at each tip end. If guide arm 592 is pushed in at partial bend 592a, the guide arm 592 moves away from the guide arm 591, which is fixed. According to the operation, if partial bend 592a is being pushed in by the hand grasping the grasping part 57, and the pushing is canceled, then the guide arm 592 will return to its original position.

[0097] Moreover, an opening-and-closing switch 571 opens and closes the passage of the fluid piping 58 formed in the grasping part 57.

[0098] The wafer 9 can be held, even if only one fluid swirl formation object 52 is formed, because of the powerful attraction, and the non-contacting conveyance equipment 51 of the above-mentioned construction holds the wafer 9 by non-contacting, as in the case of each of the above-mentioned embodiments, using the outflow of the fluid swirl formed in the concave 53. Therefore, by fixing one fluid swirl formation object 52 to the end of the fluid piping 58, and by holding the grasping part 57, and operating it by hand, the wafer 9 is held freely like tweezers and can be conveyed to a desired position. When catching the wafer 9, the partial bend 592a is pushed in, which moves the guide arm 592 to the open position of the dotted lines of Fig. 13, the wafer 9 is made easy to catch, the concave part 53 is brought close to the wafer 9 with the guide arms 591, 592 in an open state, and maintenance by non-contacting is made to perform in that case, since the guide arm 591,592 was formed. Then, at the time of conveyance, pushing of partial bend 592a is canceled, the guide arm 592 returns to the original position, and the wafer 9 can be conveyed with movement of the wafer 9 prevented and stabilized by the perpendicular bending portions formed in the ends of the guide arms 591,592. Thus, like tweezers, the non-contacting conveyance equipment 51 in this fifth embodiment is free to catch and convey the wafer 9.

[0099] Although air was used as fluid, gases or liquids other than air may be used in each of the above-mentioned embodiments.

[00100] Moreover, although it was explained above that the subject held by non-contacting was a silicon wafer, the present invention is also considered ideal for holding by non-contract arbitrary subjects other than wafers.

[00101] Moreover, although each of the concave parts 3, 33, 43, and 53 were explained as having a circumference-like shape, the concave parts 3, 33, 43, and 53 may be formed with

other shapes, such as a polygon-like shape.

[00102] Next, a seventh embodiment of the non-contacting conveyance equipment of the present invention is explained with reference to Fig. 14.

[00103] Fig. 14 is a partial front sectional view of the seventh embodiment of non-contacting conveyance equipment. The construction element in the second embodiment described above is used in this seventh embodiment, and the same mark is given to the same construction element, explanation omitted.

[00104] The non-contacting conveyance equipment 61 of the seventh embodiment differs from the above-mentioned non-contacting conveyance equipment 11 of the second embodiment at the following points. First, at the point which was open for free passage of the ultrasonic air source 610, which forms two fluid supply mouths 15 in each of the fluid swirl formation objects 2, and has vibration of ultrasonic frequency for the each. Second, at a point established so that the inside of the concave part 3 of the fluid swirl formation object 2 might be faced with the ion generation source 600.

[00105] The ion generation source 600 has an electric pole needle 601 and a high-voltage power supply 602 that supplies high voltage to the electric pole needle 601, as shown in a Fig. 14. The electric pole needle 601 is formed so that the tip faces the internal space of the concave part 3 of the fluid swirl formation object 2, from a hole 603 prepared in the base 13. By supplying high voltage, ions are generated around the tip portion of the electric pole needle 601. Moreover, from the fluid supply mouth 15, the ultrasonic air supplied from the ultrasonic air source 610 is used as the supply fluid.

[00106] The electric-pole needle 601 generates ions with polarity according to the polarity of the voltage supplied. The ions are carried to the ultrasonic air supplied from the fluid supply mouth 15, and pass through to the surface of the wafer 9 held by non-contacting. The ions are attracted by the fluid outlet 16, which is open for free passage to the vacuum pump 611, and are discharged outside through the vacuum pump 611.

[00107] Usually, the removal of particles from wafers is difficult because particles tend to adhere to the wafer surface when the wafer 9 is charged. In this seventh embodiment, as mentioned above, since ions are blown and contact the surface of the wafer 9, the electrification is neutralized and adhesion of particles by static electricity is weakened. Therefore, the supply

fluid from the fluid supply mouth 15 can easily remove the particles whose adhesion was weakened, and the surface of the wafer 9 is cleaned. The removed particles are discharged with supply fluid from the fluid outlet 16.

[00108] The supply fluid in this seventh embodiment is also made into ultrasonic air. The oscillating air of this ultrasonic fluid acts to vibrate the air layer near the wafer surface and thereby exfoliates particles from the surface of the wafer 9. The action effect of particle removal is strengthened further and particles on the wafer 9 are removed more certainly. Moreover, since the wafer 9 is neutralized with ions, particle adhesion to the wafer 9 by subsequent electrification can be prevented.

[00109] In addition, in this embodiment, although the ion generation source 600 and the ultrasonic air source 610 of are used together, only one source of either two sources may be used, and the effect of particle removal will still be demonstrated. For example, without preparing an ion generation source 600 in the fluid supply mouth, the ultrasonic air source 610 is made to open for free passage and it supplies ultrasonic air fluid. Moreover, only an ion generation source 600 can be prepared in fluid supply mouth, and it will supply usual non-ultrasonic fluid. The effect of particle removal can be demonstrated in either case.

[00110] The non-contacting conveyance equipment 61 of this seventh embodiment is capable of holding and conveying a subject by non-contacting. Moreover, it can now serve as both static electricity removal equipment that neutralizes static electricity, and as cleaning equipment that removes particles by preparing an ion generation source. Moreover, it can serve as cleaning equipment that performs particle removal by using only ultrasonic air for the supply fluid. Furthermore, by making the supply fluid into ultrasonic air, while preparing an ion generation source in this equipment, this equipment can now serve as the both static electricity removal equipment and cleaning equipment, and can still realize various functions of non-contacting conveyance equipment.

[00111] Fig. 15 is a partial front sectional view of the eighth embodiment of the non-contacting conveyance equipment.

[00112] The point at which the non-contacting conveyance equipment 71 of this 8th embodiment differs from the above-mentioned non-contacting conveyance equipment 61 of the seventh embodiment is the point in the seventh embodiment which did not form the electric pole 601 of the ultrasonic air source 600 in the fluid swirl formation object 2, but was rather formed

so that the wafer 9 currently held by non-contacting might be attended. That is, the point in the eighth embodiment where an electric pole 601 is formed in the base 13, not a fluid swirl formation object 2, and the wafer 9 currently held by non-contacting is made to overlook the tip of an electric pole 601. Moreover, the eighth embodiment differs at the point where the fluid supply mouth 151 leads to the ultrasonic air source 610, formed at hole 604.

[00113] Thus, since the ions generated by the electric pole 601 contact the surface of the wafer 9, the eighth embodiment demonstrates at least the same non-contacting action effect as that of the seventh above-mentioned embodiment. In addition, although the fluid supply mouth 151 which supplies ultrasonic air in this case has an additional fluid supply mouth 15 supplying the fluid swirl formation object 2, the flux of the ultrasonic air is enough if it is the flux of the fluid which arrives at the surface of the wafer 9. And the non-contacting maintenance of the wafer 9 held by the fluid supplied to the fluid swirl formation object 2 is not affected.

[00114] Moreover, the particles removed by the ions and ultrasonic air are promptly discharged via the fluid outlet 16 prepared in two or more places of the base 13.

[00115] In addition, although the seventh and the eighth embodiments are constructed so that the ultrasonic air from the source 610 of ultrasonic air can be ionized by the electric pole 601, these may also be constructed such that the air is first ionized by the electric pole, and then fed to the ultrasonic air source, so that the ionized air may be given ultrasonic vibration. As long as the ionized ultrasonic air finally contacts the subject held by non-contacting, either construction is acceptable.

[00116] Since the present invention consists of the above-mentioned construction, the effects explained below can also be accomplished.

[00117] The present invention performs non-contacting maintenance of a subject by the use of a concave part, a flat surface, and a fluid passage. Therefore, the equipment can be easily constructed and the cost of manufacturing the equipment is reduced sharply.

[00118] Moreover, because the equipment is easily constructed, it is also easily miniaturized. So miniaturized, it can be used and inserted into spaces not used conventionally. The action range of the equipment can be extended, and conveyance movement in a narrow domain within the same process and processing equipment can also be freely performed.

[00119] Moreover, in accordance with a resupplied inside, the air blown into the concave part

serves as a fluid swirl, smoothly flowing, receiving minimal most passage resistance. Therefore, energy efficiency can be improved and energy curtailment can be realized.

[00120] Furthermore, air is made to blow off along the direction of a circumference in the concave part, it generating a fluid swirl. Therefore, the power of attraction by the negative pressure between a flat surface and a subject can be markedly increased as compared with the conventional devices, making maintenance by non-contacting perform powerfully.

[00121] The present invention may be made to attract a subject by the fluid swirl formed by two or more concave parts, increasing the power of attraction markedly, and due to such power, a subject comes to be attracted over its whole much more powerfully. Therefore, it becomes possible to correct a curvature of the subject over the whole (for example, wafer). Consequently, even the case where a large diameter subject has a curvature, the subject can be certainly held by non-contacting, and when stabilized conveyance, it can carry the subject with certainty.

[00122] A concave part is formed in a board-like base, a fluid swirl is formed therein, and non-contacting maintenance may be performed. For this reason, conventionally stacked wafers may be freely accessed and attained, even when the wafers are in a difficult to access wafer cassette, or the wafer of which stage. A wafer attained from the wafer cassette can be conveyed more smoothly and freely. Moreover, in the case where a wafer cassette is contained and loaded with the wafer, it can be freely carried in to a desired position. That is, the acts of taking out from the wafer cassette and carrying in to the wafer cassette can be performed freely, and working efficiency can be raised sharply.

[00123] Moreover, the maintenance power in which it does not contact is powerful, and even if the non-contacting conveyance equipment reverses, a maintenance state is maintainable. Moreover, the wafer can be reversed and the wafer cassette can also be loaded, reversed, and conveyed to a following distance.

[00124] Moreover, it was made to have ions from an ion supply source contact a subject. Therefore, the electrification is neutralized and adhesion of particles by static electricity to a subject is weakened. The supply fluid can easily remove particles whose static adhesion is weakened, consequently cleaning the subject.

[00125] While the invention has been described in detail with respect to specific embodiments

thereof, it will be appreciated that those skilled in the art, upon obtaining an understanding of the foregoing may readily conceive of alterations to, variations of and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto.